FINAL REPORT

DOD AFOSR Award No. F49620-03-1-0220
Density Variations and Other Parameters from UARS Wind Measurements
30 April 2005

Research Title: Global Tidal Variations in Density and Other Parameters from UARS Wind Measurements

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Research Objectives:

General:

- Improve neutral and ionospheric density specification and prediction; understand the processes responsible for thermosphere-ionosphere variability.

Specific:

- Translate UARS tidal wind measurements at 95 km to global estimates of winds, densities and temperatures due to tides propagating upwards from the lower atmosphere; and

Fiscal Year Funding Summary ($K):

In House	Capital Equip. (> $5,000 each)	Subcontr actor	Total
$48,565	N/A	N/A	$48,565

Summary of Accomplishments:

The following tasks have been completed, and results obtained:

■ A self-consistent global climatology, useful for comparing radar observations from different locations around the globe, has been created from space – based UARS horizontal wind measurements. The climatology created includes tidal structures for horizontal winds, temperature and relative density, and is constructed by fitting local (in latitude and height) UARS wind data at 95 km to a set of basis functions called Hough Mode Extensions (HMEs). These basis functions are numerically computed modifications to Hough Modes and are globally self-consistent in wind, temperature and density. We have demonstrated this self-consistency with a proxy data set, and then use a linear weighted superposition of the HMEs obtained from monthly fits to the UARS data to extrapolate the global, multi-variable tidal structure. A web site (temporarily, http://odo.colorado.edu/~asvoboda/hmes_frame.html) has been set up wherein users can obtain specifications of amplitudes and phases of diurnal temperatures, densities and winds at any latitude and longitude, and altitudes between 80 and 120 km, based on the fits to the UARS wind measurements.

■ Temperatures between 25 and 86 km measured by the Microwave Limb Sounder (MLS) experiment on the Upper

Atmosphere Research Satellite (UARS) have been analyzed to delineate diurnal, semidiurnal and terdiurnal tidal structures and stationary planetary waves. These Fourier components are determined from temperatures averaged in bins covering 5° latitude, 30° longitude and 1 hour in local time. This study confirms the presence of diurnal non-migrating tides with zonal wavenumbers s = 0, 2, -3 [s > 0 (s < 0) implying westward (eastward) propagation] and semidiurnal tides with s = 1 and 3, and some components of lesser importance, that were previously determined from UARS wind measurements near 95 km. The seasonal-latitudinal and height structures of these components are now revealed, and utilized to aid in interpreting their behaviors and ascertaining their origins. New discoveries include the terdiurnal s = 2 and s = 4 components, and trapped non-migrating diurnal tides with s = 0 and s = 2. The former are likely to arise from nonlinear interaction between the migrating (s = 3) terdiurnal tide and the stationary planetary wave with s = 1. The latter may reflect the presence of a longitude-dependent local heat source, or nonlinear interaction between migrating diurnal tidal fields driven by such a source, with local fields associated with a stationary planetary wave with s = 1. The present results provide a rich mixture of observational results to challenge both mechanistic and general circulation models of the middle atmosphere. In addition, internal consistency is established between the MLS tidal temperatures at 86 km and previously derived tidal winds at 95 km within the context of tidal theory. Although not definitive, this result is consistent with no bias in the UARS/HRDI winds at 95 km, suggesting that source of the well-known inconsistency between winds measured from the ground and space to primarily reside in the radar wind measurements.

■ Two presentations describing the above results have been made, and two journal articles have been submitted for publication.

Appendix A: In-house Activities

Instructions: Provide all information identified below for the last FY only. "Personnel" should include each scientist or engineer who contributed to the research during the year. Publication of articles derived from the research should be listed chronologically in bibliography format. Attach reprints. List only invention disclosures derived from this specific research effort. Honors may include recognition both inside and outside the academic and Air Force science & technology (S&T) communities. Extended scientific visits may include collaboration with other research programs, both foreign and US.

Personnel:

	Name	Degree	Discipline	Involvement
Air Force Employees	N/A/			
In House Employees	Ms. Xiaoli Zhang	M.S.	Data Analysis	3.0 mos.
	Prof. Jeff Forbes	Ph.D.	Atmos. Sci.	0.45 mos.
On-site Contractors	N/A			
Visitors	N/A			

Publications:

Migrating and Non-Migrating Solar Tides as Revealed by Measurements of Mesosphere Temperature by the MLS Experiment on UARS, Jeffrey M. Forbes, Dong Wu, and Xiaoli Zhang, submitted to J. Atmos. Sci., 2005.

A Space-Based Climatology of MLT Winds, Temperatures and Densities from UARS Wind Measurements, Aaron A. Svoboda, Jeffrey M. Forbes, S. Miyahara, submitted to J. Atmos. Solar-Terr. Phys., 2004.

Invention Disclosures and Patents Granted: N/A

Invited Lectures, Presentations, Talks, etc.:

Using Hough Mode Extensions (HMEs) for Comparative Data Analysis of Atmospheric Tides, by A. Svoboda, J.M. Forbes, and S. Miyahara, presented at the 2004 CEDAR Workshop, Santa Fe, NM, June 27 – July 2, 2004.

On the use of Hough Mode Extensions (HMEs) to fit Tidal Structures from SABER and TIDI Measurements, by J.M. Forbes, A. Svoboda, X. Zhang, S. Miyahara and Y. Miyoshi, presented at the Fall 2003 meeting of the AGU.

Professional Activities (editorships, conference and society committees, etc.): N/A

Honors Received (include lifetime honors such as Fellow, honorary doctorates, etc., stating year elected): N/A

Extended Scientific Visits From and To Other Laboratories: N/A

Appendix B: Off-Site Contract and Grant Activities

Instructions: Provide all information identified below for the last FY only. Publication of articles derived from the research should be listed chronologically in bibliography format. Attach reprints. List only invention disclosures derived from this specific research effort.

Publications: N/A

Invention Disclosures: N/A

Appendix C: Technology Transitions/Transfers Detailed Listing

Performer *(name, telephone, and organization)*	**Customer (s)** *(name & organization)*	**Research Result** *(scientific statement)*	**Application** *(technical benefit(s) and/or customer useB List and underline any military applications first)*	Transitioned To	Transitioned From	Application
N/A	N/A	N/A	N/A			

Note: In the last three columns enter the following codes:

Transitioned From:
AFRL = L
Industry = I
Academia = A

Transitioned To:
Industry = I
Air Force 6.2 or 6.3 = AF
Other AF, DoD, or Government = O

Application:
Product (New or Improved) = Pd
Process (New or Improved) = Pc
Other Technology Benefit = O

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13. SUPPLEMENTARY NOTES

14. ABSTRACT

A methodology is developed for fitting determinations of tidal winds using a set of basis functions called Hough Mode Extensions (HMEs), which can then be used to estimate densities, winds, temperatures and vertical velocities, in height and latitude regimes where measurements do not exist. The methodology is validated via application to output from a general circulation model, and then is applied to actual space-based measurements. A web site has been set up for user access. The method can also be used to provide monthly-mean measurement-based tidal lower boundary conditions (at any height between 80 and 100 km) for existing and future general circulation models of the thermosphere-ionosphere system. In addition, internal consistency is established between the MLS tidal temperatures at 86 km and previously derived tidal winds at 95 km within the context of tidal theory. Although not definitive, this result is consistent with no bias in the UARS/HRDI winds at 95 km, suggesting that source of the well-known inconsistency between winds measured from the ground and space to primarily reside in the radar wind measurements.

15. SUBJECT TERMS
tides, density, variability, thermosphere

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